0512241

200-BP-1 PROTOTYPE HANFORD BARRIER ANNUAL MONITORING REPORT FOR FISCAL YEAR 1999

September 1999

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1.0 INTRODUCTION

The Prototype Hanford Barrier, deployed over the 216-B-57 Crib within the 200-BP-1 Operable Unit, was constructed in 1994 to evaluate surface barrier constructability, construction costs, and physical and hydrologic performance at the field scale. The barrier was routinely monitored between November 1994 and September 1998 as part of a comprehensive *Comprehensive Environmental Response, Compensation, and Liability Act of 1981* (CERCLA) treatability test of barrier performance. The results of the 4-year (fiscal years [FY] 1995-1998) treatability test is documented in the *200-BP-1 Prototype Barrier Treatability Test Report* (DOE-RL 1999). Based on continued monitoring recommendations provided in DOE-RL (1999), three activities were performed in FY 1999, including the following:

- Civil survey
- Vegetation survey
- Animal intrusion survey.

2.0 CIVIL SURVEY

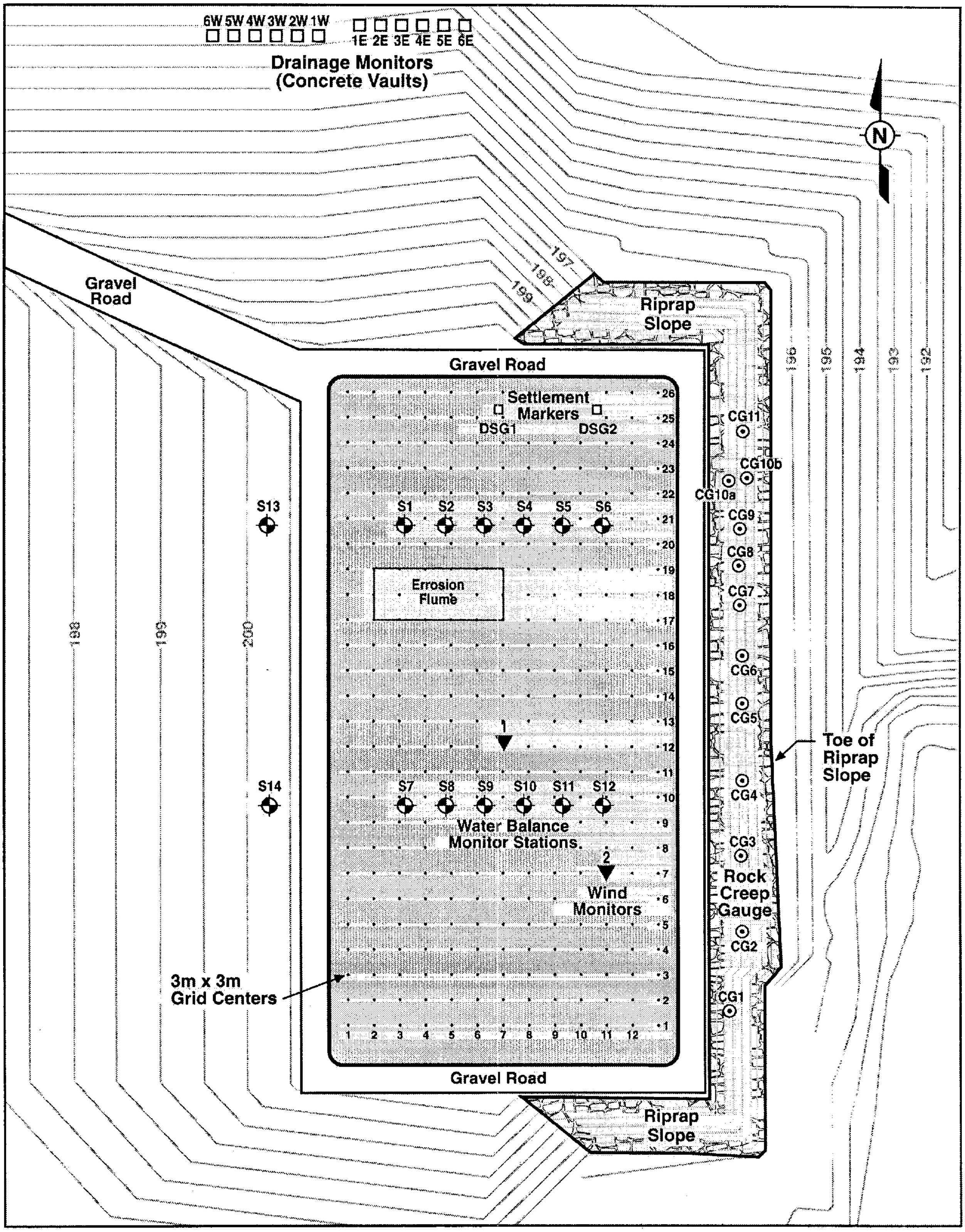
The objective of this task was to monitor the stability of the barrier by measuring elevation changes in the subgrade below the asphalt layer and the surface soil layer, and displacements in the riprap side slope. The scope of the effort involved elevation surveys at the surface 3-m by 3-m grid stakes (338 stakes total) and 2 settlement markers, and displacement (vertical and horizontal) surveys of the 12 creep gauges. The surveys were performed on July 29, 1999. Raw survey data are provided in Appendix A.

Previous stability surveys were conducted in December 1994, July 1995, September 1995, January 1996, September 1996, January 1997, and September 1997 (DOE-RL 1999). This letter report documents the results of the most recent survey and summarizes the data relative to the previous surveys.

2.1 METHODOLOGY

The surface of the barrier was demarcated with a coordinate system established by a 3-m by 3-m grid as shown in Figure 1 (from DOE-RL 1999). Each interior grid point is marked with a wooden survey stake, numbered to identify the grid coordinate. Elevation measurements were taken at the location of each stake on the 3-m by 3-m grid using an electronic distance measurement (EDM) system. To enable monitoring of the order and magnitude of settlement in the subgrade below the asphalt layer (i.e., beneath the barrier) and within the barrier, two settlement markers were installed. One marker was installed at the northern end of the barrier (DSG1), near the crown, and the second marker was installed about 14 m to the east of the first marker (DSG 2) (Figure 1). Movement of the asphalt surface is an indicator of subgrade

Figure 1. Plan View of the Prototype Hanford Barrier's Surface Showing the 3-m by 3-m Grid, Settlement Markers, and Creep Gauges.



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settlement and is quantified by measuring the change in the elevation of the top of the settlement marker rods. To enable monitoring of the riprap side slope stability, creep gauges were installed at 11 locations (CG 1 through CG 11) in the eastern slope (Figure 1). At each location, a gauge is located at the mid-slope on the riprap, except for one location near the northeast corner where two gauges are installed, one (CG10a) at the upper and the other (CG10b) at the lower slope position. Additional descriptions of the monitoring stations can be found in DOE-RL (1999).

2.2 RESULTS

2.2.1 Surface Elevation

Figure 2 compares contour plots of surface elevation taken in July 1999 (Figure 2a), September 1997 (Figure 2b), and December 1994 (Figure 2c). There was a small increase in elevation between December 1994 and July 1999, but the elevation declined between September 1997 and July 1999. Figure 3 shows a cross section of elevation at the midpoint of the barrier corresponding to each of the three plots shown in Figure 2. This plot shows an asymmetric surface with the slope to the east being steeper. The east slope was 2.46% in 1994, 2.58% in 1997, and 2.49% in 1999, while the west slope was 1.44% in 1994, 1.45% in 1997, and 1.43% in 1999.

Figure 4 shows a three-dimensional plot of the original surface elevation of the barrier in 1994 with a contour overlay of the elevation changes in July 1999. Following construction, there was a general increase in elevation on the northern irrigated portion of the surface. This increase was attributed to the combined effects of increasing plant root biomass and freeze-thaw cycles. Figure 4 shows notable decreases in elevation at the extremities of the barrier. The largest amount of settlement has been observed in the northeastern and southeastern corners and has been ongoing since monitoring started. Along the northern end of the barrier, there was a decrease in elevation along the width of the barrier. The cause is unknown, but could be an end effect. The decrease in elevation at the western edge (30 m north) was caused by the removal of the first erosion flume.

Figure 5 shows a three-dimensional plot of original surface elevation in 1994 with a contour overlay of the elevation changes between September 1997 and July 1999. The surface appears to have undergone a general decrease in elevation and may be related to the discontinuation of irrigation. As shown in Figure 4, elevation increased, mostly to the north, where the barrier was irrigated, while it decreased in the southern section. The decrease between September 1997 and July 1999 is the first general decrease in elevation since monitoring began and is likely due to a reduction in biomass, as well as the absence of freeze-thaw cycles during the last winter (winter of 1998-1999). Soil temperature data verify the absence of freezing conditions in the near surface during the last winter. As shown in Figure 4, the surface is still higher on the northern half than it was in 1994.

Figure 2. Contour Plots of Surface Elevations at the Prototype Hanford Barrier. ([a] elevation measured in July 1999, [b] elevation in September 1997, and [c] elevation in December 1994. All elevations are in meters

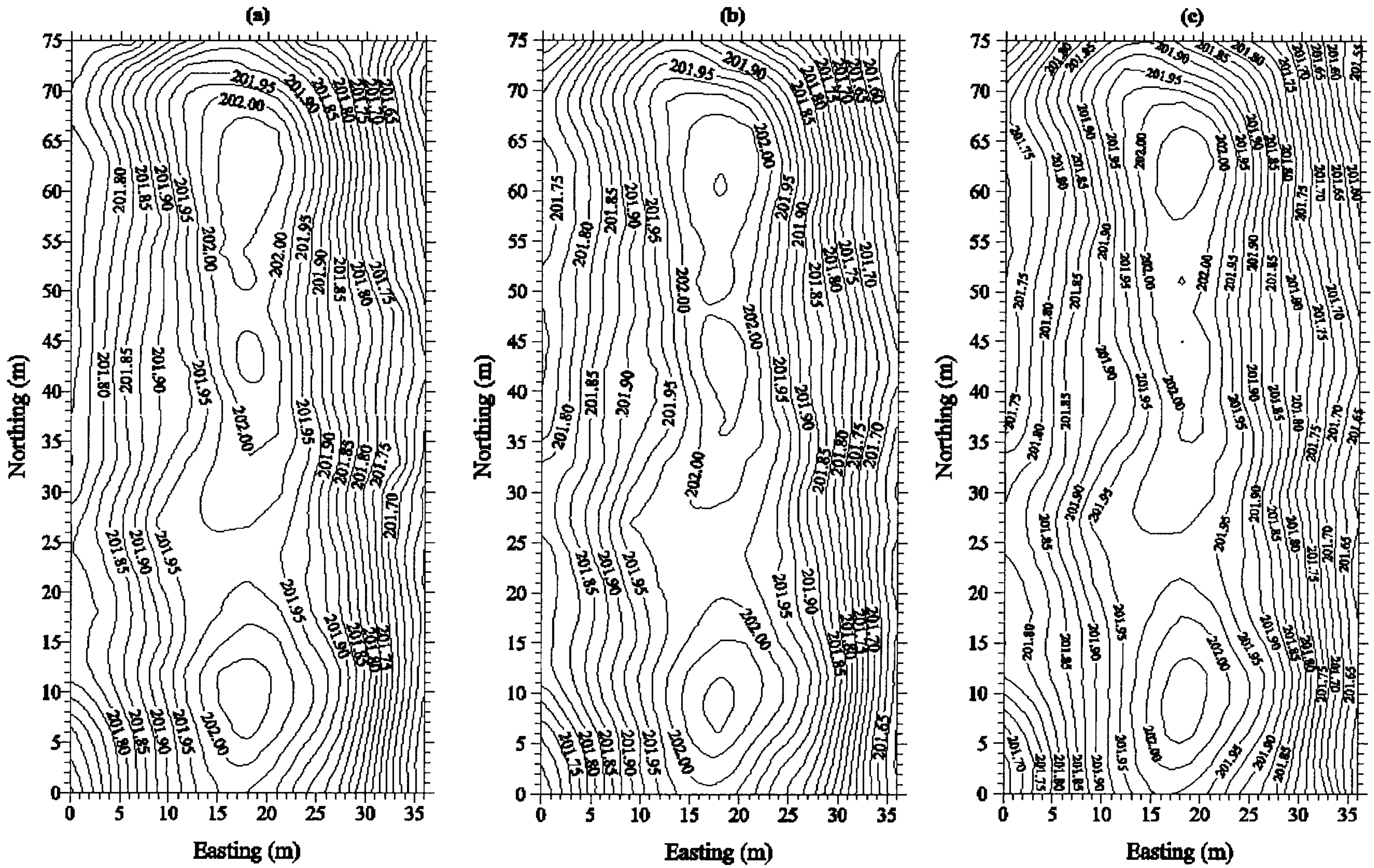


Figure 3. Elevation Profile at the Midpoint of the Prototype Hanford Barrier from West to East (Vertically Exaggerated).

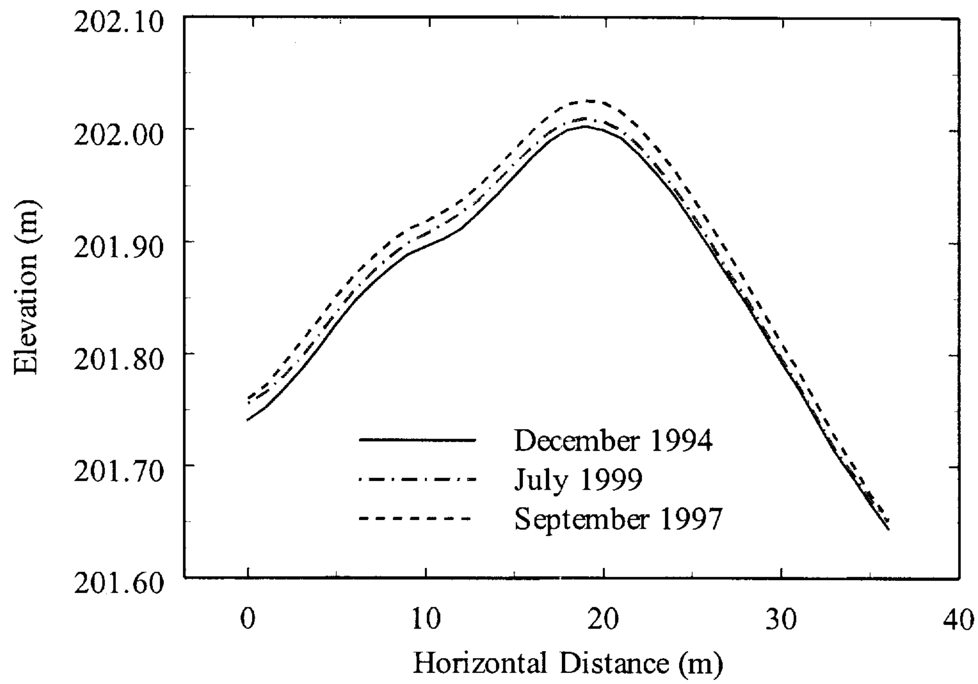


Figure 4. Changes in Surface Elevation (Vertically Exaggerated) at the Prototype Hanford Barrier in December 1994. The overlain contours (spaced at 0.01 m) with shading show the locations of surface changes in elevation from December 1994 to July 1999.

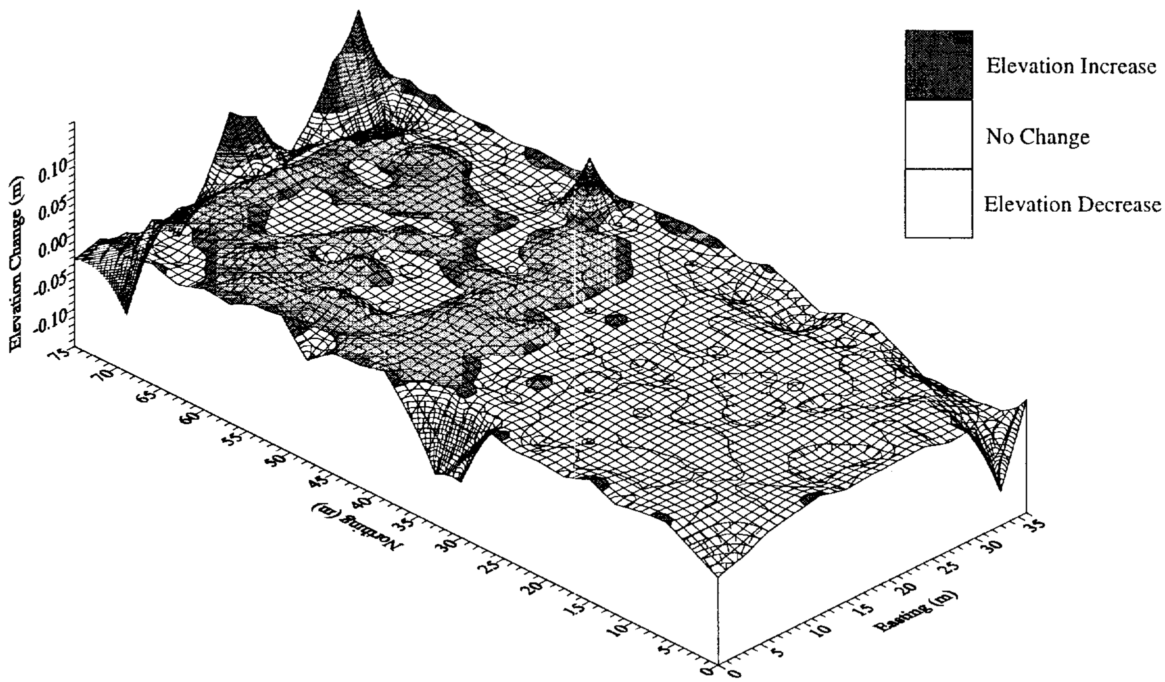
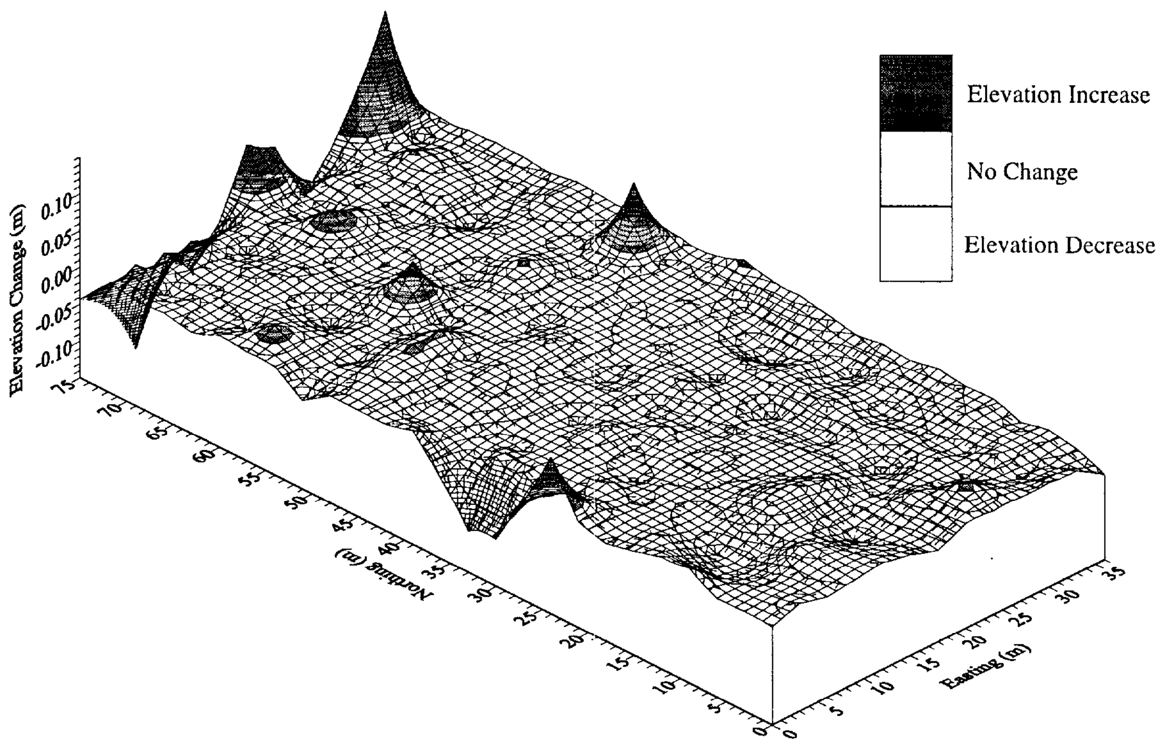


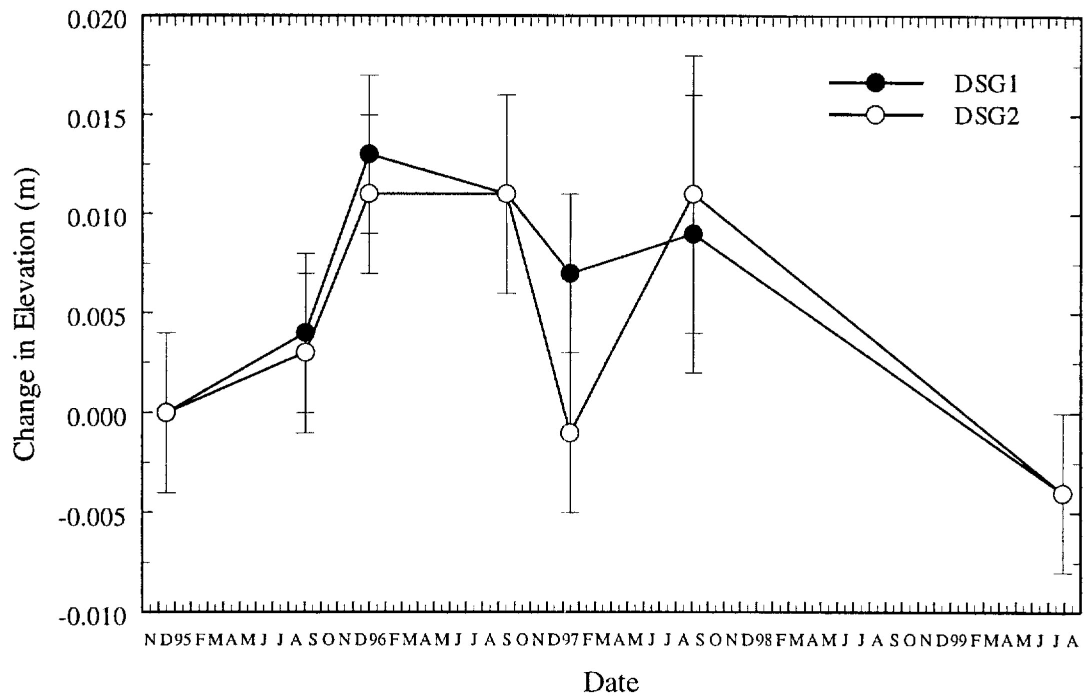
Figure 5. Changes in Surface Elevation (Vertically Exaggerated) at the Prototype Hanford Barrier in December 1994. The overlain contours (spaced 0.01 m) with shading show the location of surface changes in elevation from September 1997 to July 1999.



2.2.2 Settlement Gauges

Figure 6 shows a plot of settlement gauge elevation changes between December 1994 and July 1999. No measurements were taken in 1998. The general trend between 1994 and 1997 is an increase in elevation. The greatest elevation change occurred between the first survey in 1994 and the third survey in January 1996. Both gauges showed little movement until September 1996, after which both showed a decline in elevation. This trend has continued, with the most recent measurement in July 1999 showing a 0.004-m (4-mm) decline on both gauges. This change is very close to the limits of resolution of the EDM, but is significant when compared to the previous elevation measurement. Overall, the result is not significantly different from the first survey in 1994.

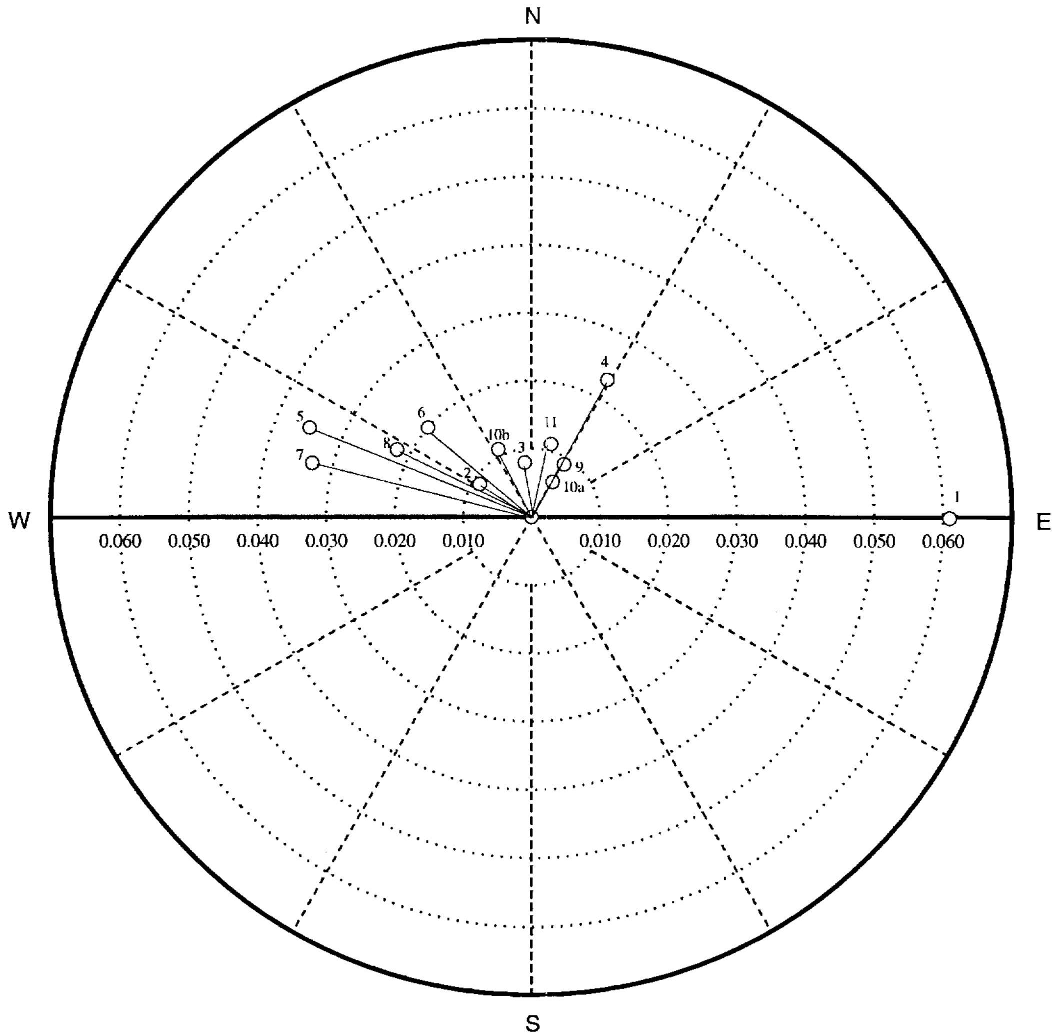
Figure 6. Summary of Cumulative Change in Settlement Gauge Elevation at the Prototype Hanford Barrier Between December 1994 and July 1999.



2.2.3 Creep Gauges

Figure 7 shows the displacement vectors for the 12 creep gauges between December 1994 and July 1999. Between 1994 and 1999, the movement of the gauges has been generally random, indicative of settlement of the riprap side slope into a more compact stable arrangement (Ward et al. 1997). Measurements between December 1994 and September 1997 showed movement to the east, with most gauges showing horizontal displacement of 2.5 cm or less, except for CG1, which moved about 3.8 cm (DOE-RL 1999). Figure 7 shows continued easterly movement on CG1, which is now approximately 6 cm east of its original location.

Figure 7. Creep Gauge Movement Between December 1994 and July 1999 at the Prototype Hanford Barrier. (Measurements were made by EDM; the resultant [horizontal component] is in meters.)



To obtain a clear time history of creep gauge movement, the data were plotted as a function of time for individual gauges, relative to the first survey. The results are presented in Figures 8 through 10. The first survey is represented by the point at the center of the plot.

Figure 8. Cumulative Creep Gauge Movement Between December 1994 and July 1999 at the Prototype Hanford Barrier. ([a] CG 1, [b] CG2, [c] CG3, and [d] CG4. Measurements were made by EDM; the resultant [horizontal component] is in centimeters.)

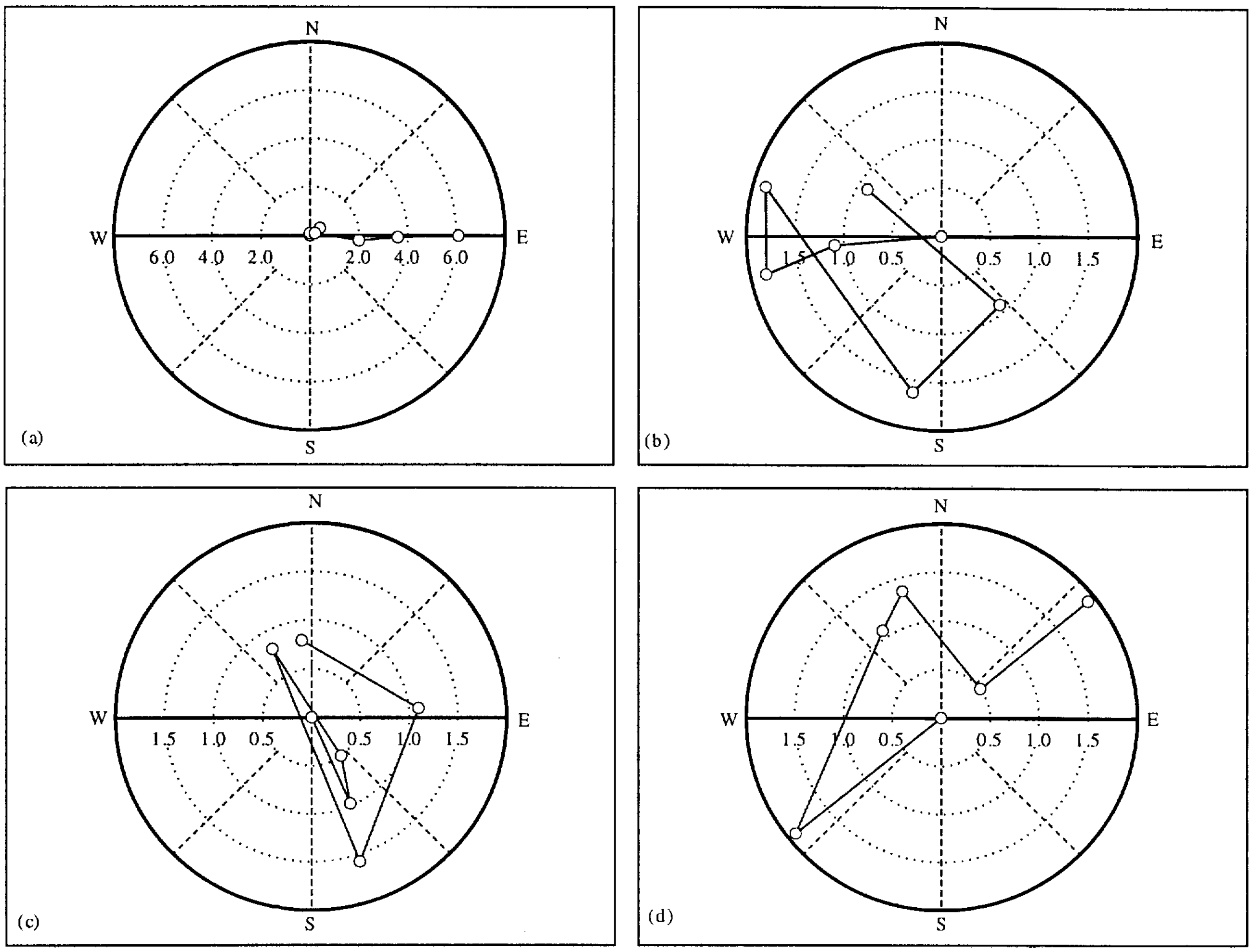


Figure 9. Cumulative Creep Gauge Movement Between December 1994 and July 1999 at the Prototype Hanford Barrier. ([e] CG 5, [f] CG6, [g] CG7, and [h] CG8. Measurements were made by EDM; the resultant [horizontal component] is in centimeters.)

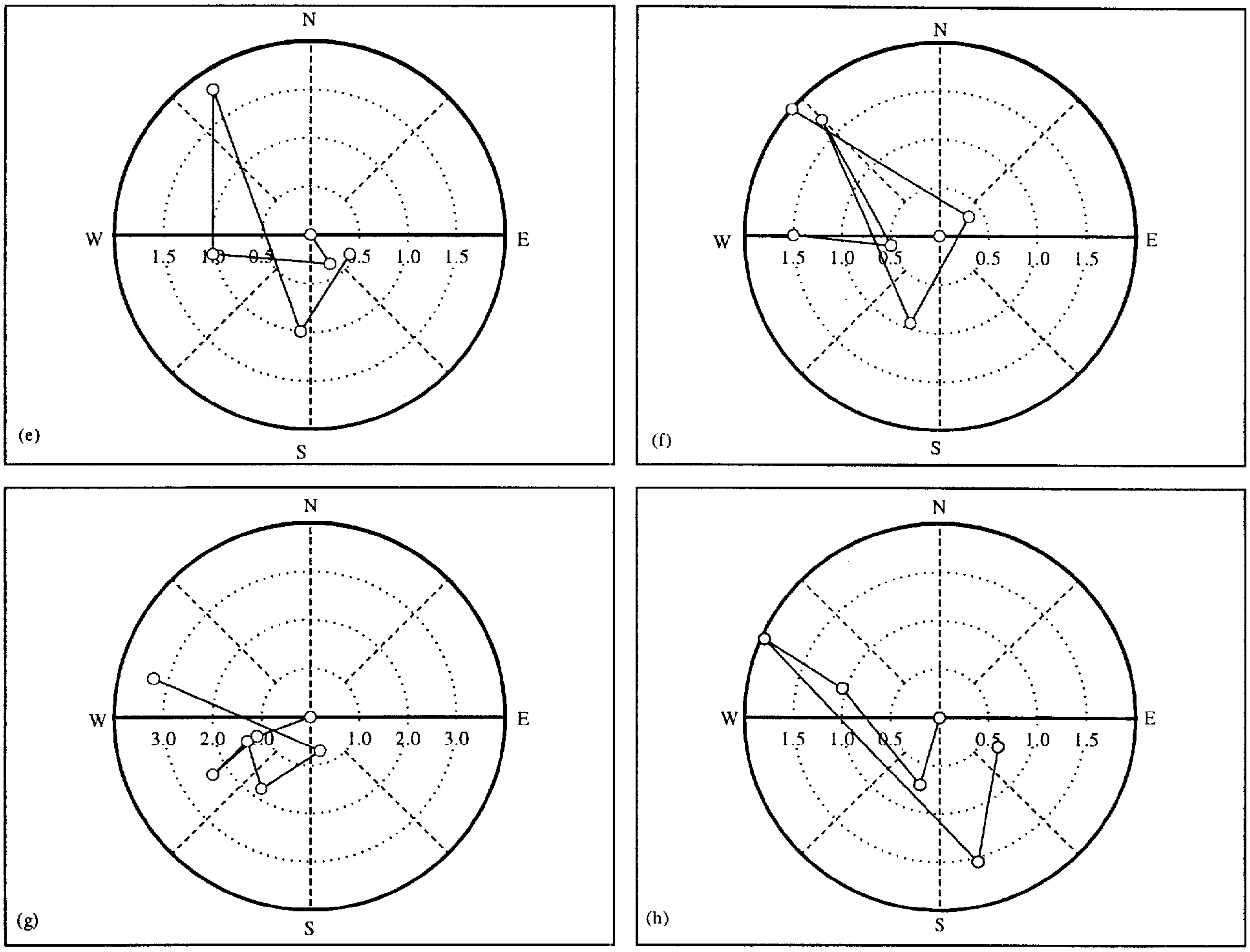
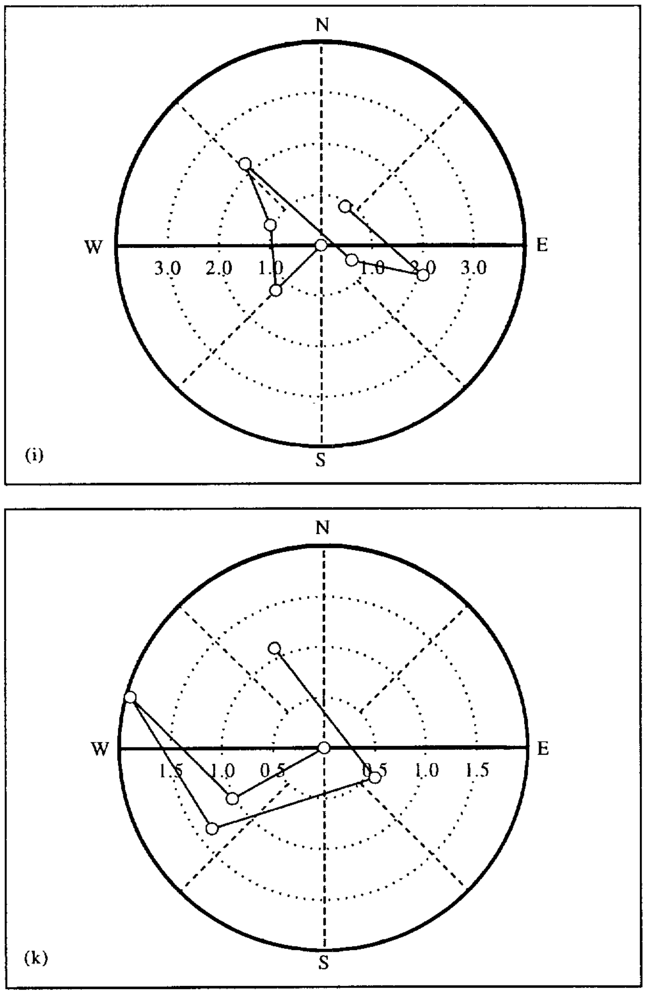


Figure 10. Cumulative Creep Gauge Movement Between December 1994 and July 1999 at the Prototype Hanford Barrier. ([i]CG9, [j] CG10a, [k] CG10b, and [l] CG11. Measurements were made by EDM; the resultant [horizontal component] is in centimeters.)



Movement between 1994 and 1999 shows no consistent trend in bearing, and the horizontal resultant has been mostly less than 2 cm. The exception is CG1, which has shown an increase in the rate of movement and a consistency in the direction of movement (east). These data suggest an outward movement of the slope. Creep gauge CG1 is adjacent to the southeastern corner of the barrier, which has shown a consistent decrease in surface elevation since construction (Figure 4). Furthermore, CG1 is located where the riprap side slope is at its steepest (approximately 1:1), and the measured displacements may represent localized instability.

2.3 SUMMARY

The Prototype Hanford Barrier was constructed with monitoring equipment to evaluate barrier stability, including surface grid stakes to measure surface topographic changes and settlement of the upper silt-loam layer, settlement gauges on the asphalt layer to measure subgrade settlement, and creep gauges to measure displacement in the steep (up to 1:1) riprap side slope. Stability measurements were initiated in 1994 and were continued in 1995, 1996, 1997, and 1999.

The data show a general increase in elevation on the northern half of the barrier during the period when the barrier was irrigated. This increase has been attributed to increases in plant biomass and freeze-thaw cycles. During the same period, a decline in elevation was observed on the southern, nonirrigated section and along the extremities of the cover. The decline along the extremities, particularly in the southeastern corner, may be due to localized settlements from end effects. Between September 1997 and July 1999, the entire cover has shown a decline in elevation, most likely a reflection of the discontinuation of irrigation and lack of freeze-thaw cycles.

The settlement gauges showed an upward trend in elevation change until September 1996 when a decrease was first observed. This trend has continued into the most recent measurements with both gauges showing a decline of 0.004 m relative to the first survey. While this decline is significant relative the previous measurement in September 1997, the current elevation is not significantly different from that observed during the first survey in December 1994.

Between 1994 and 1999, the riprap side slope creep gauges showed movement that was mostly random, indicative of the slope settling into a more compact and stable arrangement. The outlier CG1, located at the southeastern corner of the barrier, has shown consistent horizontal movement. This gauge has shown an increasing rate of movement in a consistently easterly direction. It is currently located 6 cm east of its original location. This movement is consistent with an outward displacement of this section of the riprap slope, which also coincides with the steepest part of the slope and localized decreases in elevation along the southeast edge of the silt-loam surface. This may represent a localized area of instability that should continue to be monitored.

3.0 VEGETATION SURVEY

The objective of this task was to monitor changes in plant species and cover, and shrub dimensions and survivorship. Shrub species planted on the barrier include sagebrush (*Artemisia tridentata*) and gray rabbitbrush (*Chrysothamnus nauseous*). Vegetation surveys were conducted on May 12, June 9, and August 4, 1999. Raw survey data are provided in Appendix B and in logbook EL-1509 (Weiss 1999).

Previous vegetation surveys were conducted in 1995, 1996, 1997, and 1998 (DOE-RL 1999). This letter report documents the results of the most recent survey and summarizes the data relative to the previous surveys.

3.1 METHODOLOGY

Vegetative parameters measured were shrub height, canopy area, and survivorship; cover classes for grass, shrubs, litter, and bare ground; and plant species present. The maximum height, width, and length of 25 shrubs each in the northern (irrigated in 1995, 1996, and 1997) and southern (nonirrigated) sections of the barrier surface were measured consistent with the methods used in DOE-RL (1999). The height of the highest stem, and the greatest canopy diameter and the diameter perpendicular to the greatest diameter, were measured. The measured shrubs were chosen randomly, regardless of species (sagebrush or gray rabbitbrush).

Shrub survivorship was calculated on the basis that the shrubs were planted at equivalent distances (1 m) from each other (DOE-RL 1999). Eight rows of shrubs were counted in both the north and south sections. All live plants in each row were counted, as well as "holes" where it was assumed a shrub had died or been removed. Only a few dead stems were seen in these holes, however. No reliable estimate could be made as to the species of plants that died, since little evidence remains. However, 1,350 rabbitbrush and 4,500 sagebrush seedlings were originally planted in 1995 at a 1:3 ratio (25% rabbitbrush) on the north and south sections (DOE-RL 1999). Shrubs seedlings were planted two to a location. The number of each species of live shrubs were counted in 10 rows on the northern side and 12 rows on the southern side to determine the percent of each species remaining, from which the survivorship of each species was calculated.

Cover classes of shrubs, grasses, forbs, litter, and bare ground were estimated using the technique of Daubenmire (1959) and DOE-RL (1999). The plant species on the northern and southern sections of the barrier, and the barrier side slope, were identified and compared to previous years.

3.2 RESULTS

In the southern, nonirrigated section, 4 of the 25 plants measured for height and area were rabbitbrush. In the northern, previously irrigated section, 3 of the 25 plants were rabbitbrush. Because of these low sample numbers, the average measurements and heights of the rabbitbrush will vary from year to year more than sagebrush will. Regardless, qualitative observations show that rabbitbrush, especially on the formerly irrigated side, appears to be dying back, which matches the quantitative measurements. The rabbitbrush plants were under visible stress, and many had only a few live branches. Summary data from the measurements are shown in Table 1.

Table 1. Summary Data of Shrub Measurements Taken on the Prototype Hanford Barrier in 1999 (1998 Measurements are Shown in Brackets).

	North (Irrigated)		South (Nonirrigated)	
	Average	Range	Average	Range
Sagebrush				
Area (cm^2)	2,420 [2,198]	194 – 4,600 [600 - 10,450]	3,034 [2,586]	1,080 – 6,375 [225 - 4,875]
Height (cm)	67 [59]	28 – 86 [40 – 101]	65 [63]	45 – 95 [40 – 85]
Rabbitbrush				
Area (cm^2)	1,357 [2,606]	426 – 1,839 [1,575 - 5,040]	1665 [1,225]	486-2604 [450 - 2,000]
Height (cm)	48 [57]	46 – 51 [40 – 70]	41 [45]	38 – 45 [39 – 50]

The shrub survivorship results, rounded to the nearest whole percent, are presented in Figure 11. Calculated increases in survivorship in 1999, as presented, are not logically possible. The calculated increases may be due to differences in counting methodologies between years in relation to the growth of shrubs that were planted together. Because two seedlings were planted in each location in 1995, the growth form of these shrubs made determining if one or two shrubs were still present in each location by 1999 difficult. Consequently, for each location, if a shrub was alive, it was assumed in 1999 that only one shrub was present. If previous year's counts were able to reliably distinguish whether one or two shrubs were still alive at each location, and only one shrub was present at many sites, the survivorship would be lower than if it was assumed that only one shrub was planted at each location.

The mean, median, and mode for the north and south sides are shown in Table 2 (the ranges shown are the cover classes as defined by Daubenmire [1959]). In general, the previously irrigated section had much heavier growth of grasses toward the north end, thinning to a cover roughly equivalent to the south section as it approached the southern, nonirrigated section. The northern area, irrigated in 1995, 1996, and 1997, was not irrigated in 1998 or 1999. In addition, spring 1999 rainfall was far below normal (0.06 in. in March and only a trace of rain in April); consequently, much of the grass cover was dried grass stems from previous years. Native bunchgrasses appeared to be well established over the grid, with relatively little cheatgrass (*Bromus tectorum*) or tumbleweed (*Salsola kali*) from this year's growth.

The cover on the gravel side slopes was not uniform, but denser at the bottom and very sparse more than halfway up the slope. The distribution most likely reflects more available moisture in the soil closer to the bottom of the slope.

Table 3 shows the species identified on the irrigated versus the nonirrigated, Table 4 shows those species identified on the side slopes, and Table 5 compares the species identified this year on the surface of the barrier versus those identified 1995 to 1997 (from DOE-RL 1999). Figure 12 shows the changes in annual and perennial abundances from 1995 to 1999. A species list was not compiled in 1998.

Figure 11. Mean Survivorship for Sagebrush (*Artemisia tridentata*) and Gray Rabbitbrush (*Chrysothamnus nauseosus*) in WY 1995, WY 1996, and WY 1997 for the Nonirrigated and Irrigated Treatments.

(Error bars are one standard error of the mean. Means with differing letters within years and species are significantly different.)

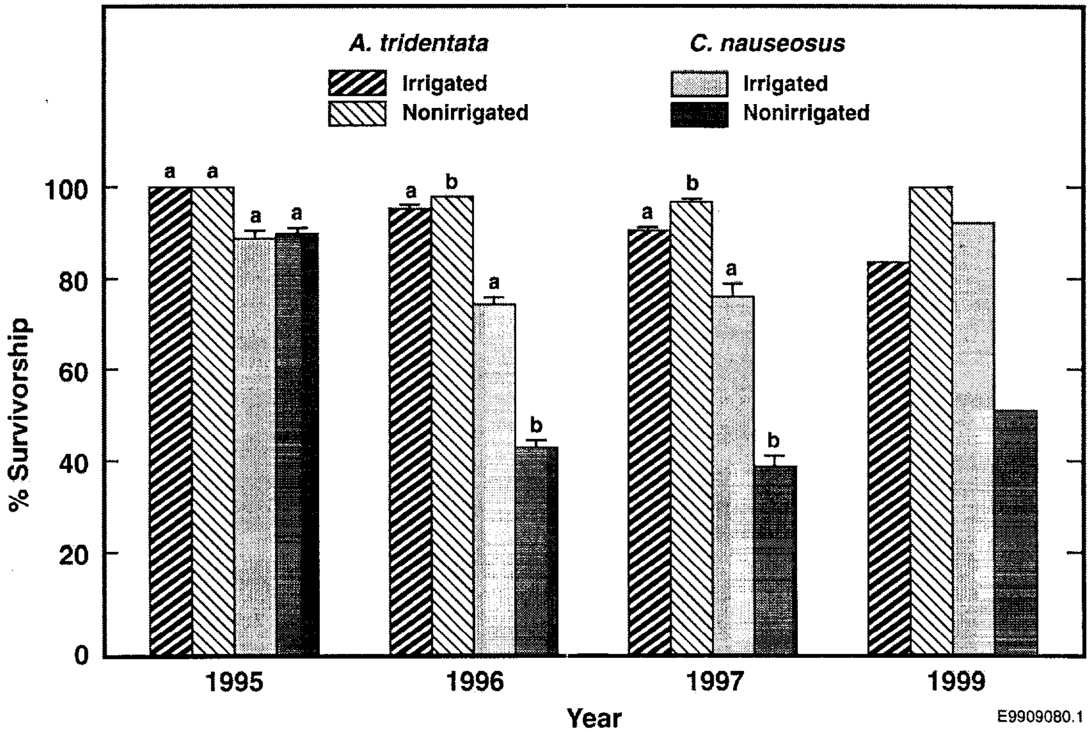


Table 2. Median and Mode of the Percent Cover Classes.

Cover Class	Treatment	Water Year	Median	Mode	Mean
Grass	Irrigated	1996	25-50	5-25	
		1997	50-75	50-75	
		1999	75-95	75-95	50-75
	Nonirrigated	1996	5-25	5-25	
		1997	25-50	25-50	
		1999	25-50	5-25	25-50
Shrub	Irrigated	1996	0-5	0-5	
		1997	25-50	25-50	
		1999	25-50	25-50	25-50
	Nonirrigated	1996	0-5	0-5	
		1997	25-50	25-50	
		1999	25-50	25-50	25-50
Herbaceous	Irrigated	1996	0-5	0-5	
		1997	0-5	0-5	
		1999	0-5	0-5	0-5
	Nonirrigated	1996	0-5	0-5	
		1997	0-5	0-5	
		1999	0-5	0-5	0-5
Litter	Irrigated	1996	5-25	5-25	
		1997	50-75	50-75	
		1999	75-95	95-100	75-95
	Nonirrigated	1996	5-25	5-25	
		1997	25-50	25-50	
		1999	5-75	75-95	50-75
Bare	Irrigated	1996	5-25	5-25	
		1997	5-25	25-50	
		1999	5-25	0-5	5-25
	Nonirrigated	1996	5-25	5-25	
		1997	25-50	25-50	
		1999	5-25	5-25	25-50

Table 3. Plant Species Observed in 1999 on the Surface of the Prototype Hanford Barrier, Formerly Irrigated and Nonirrigated Sections.

Species	North (Irrigated)	South (Nonirrigated)
Amsinckia lycopsoides (Tarweed fiddleneck)	x	x
Cardaria draba (Whitetop)		x
Draba verna (Spring whitlowgrass)		x
Sisymbrium altissimum (Tumblemustard)	x	
Salsola kali (Russian thistle)	x	x
Achillaea millifolium (Yarrow)	x	
Artemisia tridentata (Big sagebrush)	x	x
Chrysothamnus nauseosus (Gray rabbitbrush)	x	x
Lactuca serriola (Prickly lettuce)	x	x
Machaeranthera canescens (Hoary aster)	x	x
Tragopogon dubius (Yellow salsify)	x	x
Erodium cicutarium (Storksbill)		x
Astragalus spp.	x	x
Melilotus alba (White sweetclover)	x	
Sphaeralcea munroana (Munro's globemallow)	x	x
Epilobium paniculatum (Tall willowherb)		x
Agropyron cristatum (Crested wheatgrass)		x
Bromus tectorum (Cheatgrass)	x	x
Poa ampla (Sherman's big bluegrass)	x	x
Poa bulbosa (Bulbous bluegrass)		x
Poa sandbergii (Sandberg's bluegrass)		x
Holosteum umbellatum (Jagged chickweed)		x
Agastache occidenatalis (Western horsemint)	x	

Table 4. Plant Species Observed in 1999 on the North and West Gravel Side Slopes of the Prototype Hanford Barrier.

Amsinckia lycopsoides (Tarweed fiddleneck)	*Astragalus spp.*
Descurainia pinnata (Western tansymustard)	*Melilotus alba* (White sweetclover)
Draba verna (Spring whitlowgrass)	*Epilobium paniculatum* (Tall willowherb)
Sisymbrium altissimum (Tumblemustard)	*Agropyron cristatum* (Crested wheatgrass)
Salsola kali (Russian thistle)	*Bromus tectorum* (Cheatgrass)
Achillaea millifolium (Yarrow)	*Oryzopsis hymenoides* (Indian ricegrass)
Artemisia tridentata (Big sagebrush)	*Poa bulbosa* (Bulbous bluegrass)
Chrysothamnus nauseosus (Gray rabbitbrush)	*Poa sandbergii* (Sandberg's bluegrass)
Lactuca serriola (Prickly lettuce)	*Holosteum umbellatum* (Jagged chickweed)
Machaeranthera canescens (Hoary aster)	*Chaenactis douglasii* (Hoary falseyarrow)
Tragopogon dubius (Yellow salsify)	*Penstemon spp.*
Erodium cicutarium (Storksbill)	

Table 5. Plant Species Observed on the Prototype Surface Barrier. (3 Pages)

Scientific Name		Common Name	Species	Presence (WY)				Life Form
Family	Species			1995	1996	1997	1999	
Boraginaceae	*Amsinckia lycopsoides*	Devil's lettuce	N	X	X	X	X	Annual forb
Brassicaceae	*Cardaria draba*	Whitetop	I		X	X	X	Perennial forb
	Chorispora tenella	Blue mustard	I	X		X		Annual forb
	Descurainia pinnata	Western transymustard	N	X	X	X		Annual forb
	Draba verna	Spring whitlowgrass	I	X	X	X	X	Annual forb
	Sisymbrium altissimum	Jim Hill tumblemustard	I	X	X	X		Annual forb
Carhophyllaceae	*Holosteum umbellatum*	Jagged chickweed	I				X	Annual forb
Chenopodiaceae	*Chenopodium leptophyllum*	Slimleaf goosefoot	N	X	X	X		Annual forb
	Salsola kali	Russian thistle	I	X	X	X	X	Annual forb
Compositae	*Achillaea millifolium*	Yarrow	N	X		X	X	Perennial forb
	Ambrosia acanthicarpa	Bur ragweed	N	X		X		Perennial forb

Table 5. Plant Species Observed on the Prototype Surface Barrier. (3 Pages)

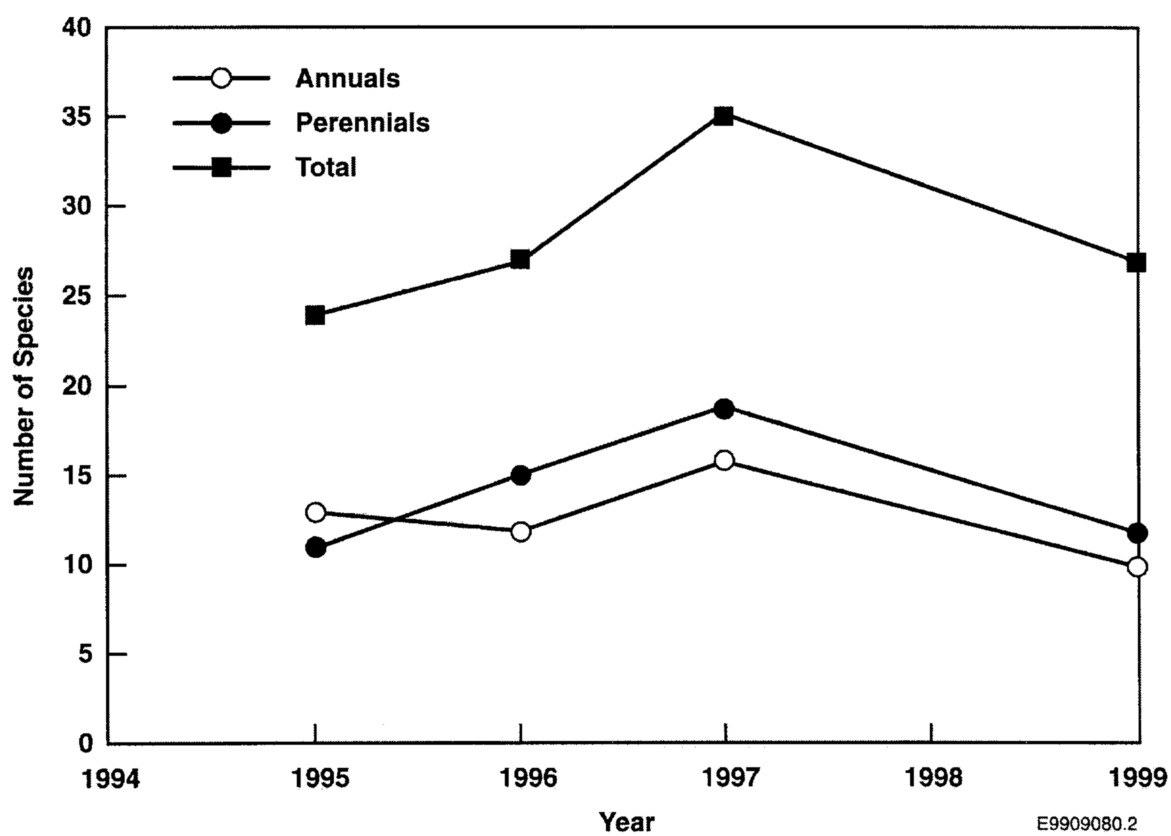
Scientific Name		Common Name	Species	Presence (WY)				Life Form
Family	Species			1995	1996	1997	1999	
Compositae (cont.)	*Artemisia tridentata*	Big sagebrush	N, R	X	X	X	X	Perennial shrub
	Chrysothamnus nauseosus	Gray rabbitbrush	N, R	X	X	X	X	Perennial shrub
	Chrysothamnus viscidiflorus	Green rabbitbrush	N			X		Perennial shrub
	Conyza canadensis	Horseweed	N			X		Annual forb
	Lactuca serriola	Prickly lettuce	I	X	X	X	X	Annual forb
	Machaeranthera canescens	Hoary aster	N		X	X	X	Biennial, perennial forb
	Tragopogon dubius	Yellow salsify	I		X	X	X	Annual forb
Convolvulaceae	*Convolvulus arvensis*	Field bindweed	I		X	X		Perennial forb
Geraniaceae	*Erodium cicutarium*	Storksbill	I	X	X	X	X	Annual forb
Hydrophyllaceae	*Phacelia linearis*	Threadleaf scorpionweed	N	X				Annual forb
Lamiaceae	*Agastache occidentalis*	Western horsemint	N				X	Perennial forb
Leguminosae	*Astragalus sp.*	Milkvetch	N			X	X	Perennial forb
	Lupinus pusillus	Low lupine	N			X		Annual forb
	Melilotus alba	White sweetclover	I		X	X	X	Annual forb
Malvaceae	*Sphaeralcea munroana*	Munro's globemallow	N		X	X	X	Perennial forb
Onagraceae	*Epilobium paniculatum*	Tall willowherb	N		X	X	X	Annual forb
Poaceae	*Agropyron cristatum*	Crested wheatgrass	I		X	X	X	Perennial grass
	Agropyron dasytachyum	Thickspike wheatgrass	N, R	X	X	X		Perennial grass
	Agropyron intermedium	Intermediate wheatgrass	I		X	X		Perennial grass
	Bromus tectorum	Cheatgrass	I	X	X	X	X	Annual grass
	Oryzopsis hymenoides	Indian ricegrass	N, R	X	X	X		Perennial grass
	Poa ampla	Sherman's big bluegrass	R	X	X	X	X	Perennial grass
	Poa bulbosa	Bulbous bluegrass	I	X	X	X	X	Perennial grass

Table 5. Plant Species Observed on the Prototype Surface Barrier. (3 Pages)

Scientific Name		Common Name	Species	Presence (WY)				Life Form
Family	Species			1995	1996	1997	1999	
Poaceae (cont.)	*Poa sandbergii*	Sandberg's bluegrass	N, R	X	X	X	X	Perennial grass
	Pseudoroegneria spicata	Bluebunch wheatgrass	N, R	X	X	X		Perennial grass
	Sitanion hystrix	Bottlebrush squirreltail	N, R	X				Perennial grass
	Stipa comata	Needle-and-thread grass	N, R	X		X		Perennial grass
	Triticum aestivum	Wheat	I	X				Annual grass
Verbenaceae	*Verbena bracteata*	Bracted verbena	N		X	X		Perennial forb

I = invasive alien species
N = native species
R = species hydroseeded
WY = water year

Figure 12. Number of Annual and Perennial Species Including Total Species on the Prototype Hanford Barrier's Surface.



3.3 SUMMARY

Sagebrush survivorship is most likely related to competition. The northern side, where the barrier was formerly irrigated, had much greater growth of grasses, which would have competed with the sagebrush for moisture. Because sagebrush usually comes into an area as part of secondary succession, the seedlings planted may not be as competitive as grasses shortly after a disturbance. Rabbitbrush, a strong invader species, is better able to compete against other invader species, such as the grasses. Grasses would have been given a strong competitive advantage with the addition of the irrigation, thus causing sagebrush, but not rabbitbrush, to be at a competitive disadvantage in the irrigated section.

The effects of competition for moisture are visible in mid-summer at the barrier by observing the condition of the shrubs along the perimeter. Shrubs that have competition only on three sides (those on the perimeter) were doing significantly better during the stressful heat and dryness of the summer than are those on the interior.

Qualitative and quantitative evaluations of the barrier show high survivorship of native plants on the top of the barrier. Changes in the vegetative makeup will continue for the next several years, as the effects of the lack of irrigation continue to evolve. However, sagebrush survival is expected to continue to be high, and rabbitbrush survival should continue to decrease as it is out-competed by sagebrush. The perennial grasses already established in the south side should also continue to survive as they are, with yearly changes in individual growth patterns reflecting rainfall distribution and amount for that year.

In 1999, the number of species had declined from 35 in 1997 to 22. This may be a result of several factors, including the cessation of irrigation, a very dry spring, and normal plant succession to a more stable community of perennial species and fewer annual species. The 23 species on the gravel side slopes more closely match the surrounding native community and are probably a result of natural revegetation rather than from the initial barrier planting.

4.0 ANIMAL INTRUSION SURVEY

The objective of this task was to survey for evidence of animal intrusion into the barrier. Animal-use surveys were conducted on May 12 and August 4, 1999. Previous animal-use surveys were conducted in 1995, 1996, 1997, and 1998 (DOE-RL 1999). This letter report documents the results of the most recent survey and summarizes the data relative to the previous surveys. Raw survey data are provided in logbook EL-1509 (Weiss 1999).

4.1 METHODOLOGY

Each of the 3-m by 3-m grid blocks on the barrier surface (Figure 1) was examined on May 12, 1999, for evidence of animal burrowing. The site was again surveyed randomly on August 4 to identify any new burrowing. Burrowing on the north and west gravel side slopes was also randomly surveyed concurrently with the plant identification surveys in May.

4.2 RESULTS

Most of the animal holes observed were the same as those identified in previous years and from mice; only a few new holes were observed. Slightly more cottontail rabbit use, such as shallow, grass-lined scrapes and "resting" depressions in the grass, was also seen. No new ant mounds were observed in 1999, but several new beetle or other insect holes were noted. These insect holes are normally less than 1/4 in. in diameter.

Ward et al. (1997) reported in their summary that some of the animal burrowing could be attributed to ground squirrels (*Spermophilus townsendii*). None of the holes observed in 1998 or 1999 were made by ground squirrels; they live in colonies (the holes observed did not have the distribution usually associated with a colony), and ground squirrels have larger holes than the maximum 1.5 in. observed.

4.3 SUMMARY

As with the top surface of the barrier, little new burrowing was observed on the gravel side slopes, and most of what was seen matched the previous year's observations, with rodent burrowing associated with the finer soils nearer the bottom of the slopes, and little near the top of the slopes. Only minor animal burrowing on the top and sides of the barrier was observed, and this appears to be consistent with past years (DOE-RL 1999). In future years, the animal burrowing on the top of the barrier should be expected to match the surrounding habitat.

5.0 REFERENCES

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APPENDIX A

CIVIL SURVEY MEASUREMENTS TAKEN AT THE PROTOTYPE HANFORD BARRIER, 1999

Table A-1. Prototype Hanford Barrier Surface Elevations (in Meters Above Mean Sea Level). Locations represent distance in meters from Stake 1,1 (Figure 1). (4 Pages)

December 1994																				
Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation
E	N		E	N		E	N		E	N		E	N		E	N		E	N	
0	0	201.62	30	12	201.89	15	24	201.94	0	36	201.72	24	45	201.92	9	57	201.81	33	66	201.63
3	0	201.73	33	12	201.73	18	24	201.97	3	36	201.79	27	45	201.86	12	57	201.94	36	66	201.55
6	0	201.82	36	12	201.61	21	24	201.94	6	36	201.86	30	45	201.82	15	57	202.03	0	69	201.75
9	0	201.89	0	15	201.75	24	24	201.96	9	36	201.90	33	45	201.74	18	57	202.02	3	69	201.81
12	0	201.94	3	15	201.82	27	24	201.89	12	36	201.89	36	45	201.64	21	57	202.02	6	69	201.89
15	0	201.99	6	15	201.86	30	24	201.80	15	36	201.96	0	48	201.75	24	57	201.92	9	69	201.95
18	0	201.98	9	15	201.87	33	24	201.67	18	36	202.03	3	48	201.77	27	57	201.83	12	69	202.00
21	0	201.95	12	15	201.96	36	24	201.59	21	36	202.02	6	48	201.83	30	57	201.71	15	69	202.01
24	0	201.88	15	15	201.99	0	27	201.79	24	36	201.99	9	48	201.89	33	57	201.70	18	69	202.03
27	0	201.88	18	15	202.02	3	27	201.83	27	36	201.89	12	48	201.93	36	57	201.57	21	69	201.98
30	0	201.78	21	15	202.03	6	27	201.89	30	36	201.81	15	48	202.03	0	60	201.71	24	69	201.91
33	0	201.78	24	15	201.94	9	27	202.01	33	36	201.72	18	48	201.97	3	60	201.76	27	69	201.84
36	0	201.53	27	15	201.94	12	27	201.97	36	36	201.61	21	48	201.99	6	60	201.78	30	69	201.71
0	3	201.65	30	15	201.83	15	27	202.00	0	39	201.72	24	48	201.91	9	60	201.88	33	69	201.66
3	3	201.71	33	15	201.71	18	27	201.99	3	39	201.77	27	48	201.84	12	60	201.97	36	69	201.47
6	3	201.80	36	15	201.60	21	27	201.96	6	39	201.86	30	48	201.82	15	60	202.05	0	72	201.70
9	3	201.91	0	18	201.79	24	27	201.94	9	39	201.91	33	48	201.73	18	60	202.05	3	72	201.79
12	3	201.95	3	18	201.78	27	27	201.84	12	39	201.88	36	48	201.63	21	60	202.03	6	72	201.88
15	3	202.00	6	18	201.84	30	27	201.80	15	39	201.95	0	51	201.70	24	60	201.97	9	72	201.92
18	3	202.01	9	18	201.90	33	27	201.70	18	39	202.01	3	51	201.79	27	60	201.88	12	72	201.99
21	3	201.98	12	18	201.97	36	27	201.63	21	39	202.00	6	51	201.81	30	60	201.73	15	72	201.94
24	3	201.91	15	18	201.96	0	30	201.79	24	39	201.91	9	51	201.89	33	60	201.69	18	72	201.91
27	3	201.90	18	18	202.01	3	30	201.84	27	39	201.85	12	51	201.93	36	60	201.56	21	72	201.91
30	3	201.81	21	18	202.01	6	30	201.86	30	39	201.79	15	51	202.03	0	63	201.71	24	72	201.88
33	3	201.68	24	18	201.93	9	30	201.94	33	39	201.71	18	51	202.07	3	63	201.73	27	72	201.83
36	3	201.58	27	18	201.89	12	30	201.97	36	39	201.63	21	51	202.00	6	63	201.81	30	72	201.73
0	6	201.65	30	18	201.80	15	30	201.99	0	42	201.72	24	51	201.93	9	63	201.89	33	72	201.59
18	6	202.07	33	18	201.71	18	30	201.98	3	42	201.79	27	51	201.83	12	63	202.00	36	72	201.51
21	6	202.02	36	18	201.62	21	30	202.00	6	42	201.87	30	51	201.80	15	63	202.03	0	75	201.59
24	6	201.97	0	21	201.77	24	30	201.94	9	42	201.88	33	51	201.69	18	63	202.04	3	75	201.65
27	6	201.93	3	21	201.80	27	30	201.84	12	42	201.87	36	51	201.60	21	63	202.05	6	75	201.79
30	6	201.82	6	21	201.84	30	30	201.74	15	42	201.99	0	54	201.69	24	63	201.99	9	75	201.83
33	6	201.69	9	21	201.95	33	30	201.68	18	42	202.06	3	54	201.75	27	63	201.88	12	75	201.90
36	6	201.59	12	21	201.98	36	30	201.57	21	42	202.02	6	54	201.83	30	63	201.75	15	75	201.91

Table A-1. Prototype Hanford Barrier Surface Elevations (in Meters Above Mean Sea Level). Locations represent distance in meters from Stake 1,1 (Figure 1). (4 Pages)

December 1994

Location E	Location N	Elevation	Location E	Location N	Elevation	Location E	Location N	Elevation	Location E	Location N	Elevation	Location E	Location N	Elevation	Location E	Location N	Elevation	Location E	Location N	Elevation
0	9	201.73	15	21	201.96	0	33	201.81	24	42	201.93	9	54	201.91	33	63	201.69	18	75	201.85
18	9	202.08	18	21	201.99	3	33	201.78	27	42	201.84	12	54	201.94	36	63	201.55	21	75	201.81
21	9	202.01	21	21	201.96	6	33	201.83	30	42	201.78	15	54	202.06	0	66	201.73	24	75	201.74
24	9	202.01	24	21	201.91	9	33	201.91	33	42	201.74	18	54	201.99	3	66	201.78	27	75	201.75
27	9	201.95	27	21	201.91	12	33	201.97	36	42	201.69	21	54	202.02	6	66	201.81	30	75	201.70
30	9	201.86	30	21	201.81	15	33	201.98	0	45	201.70	24	54	201.93	9	66	201.92	33	75	201.58
33	9	201.71	33	21	201.70	18	33	202.02	3	45	201.77	27	54	201.88	12	66	201.97	36	75	201.54
36	9	201.61	36	21	201.56	21	33	201.95	6	45	201.86	30	54	201.74	15	66	202.02			
0	12	201.82	0	24	201.81	24	33	201.97	9	45	201.91	33	54	201.71	18	66	202.04			
18	12	202.06	3	24	201.81	27	33	201.90	12	45	201.94	36	54	201.60	21	66	202.05			
21	12	202.04	6	24	201.89	30	33	201.78	15	45	202.01	0	57	201.73	24	66	201.95			
24	12	201.99	9	24	201.93	33	33	201.68	18	45	202.06	3	57	201.74	27	66	201.83			
27	12	201.97	12	24	201.97	36	33	201.62	21	45	202.02	6	57	201.82	30	66	201.75			

Table A-1. Prototype Hanford Barrier Surface Elevations (in Meters Above Mean Sea Level). Locations represent distance in meters from Stake 1,1 (Figure 1). (4 Pages)

July 1999																				
Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation
E	N		E	N		E	N		E	N		E	N		E	N		E	N	
0	0	201.6	3	75	201.646	3	63	201.731	6	51	201.835	9	39	201.919	12	27	201.961	15	15	201.992
3	0	201.7	0	72	201.715	0	63	201.709	3	51	201.792	6	39	201.869	9	27	202.004	12	15	201.959
6	0	201.8	3	72	201.791	0	60	201.726	0	51	201.731	3	39	201.777	6	27	201.891	9	15	201.87
9	0	201.9	6	72	201.881	3	60	201.766	0	48	201.735	0	39	201.737	3	27	201.836	6	15	201.853
12	0	201.9	9	72	201.916	6	60	201.811	3	48	201.78	0	36	201.733	0	27	201.797	3	15	201.819
15	0	202.0	12	72	201.986	9	60	201.895	6	48	201.851	3	36	201.793	0	24	201.811	0	15	201.763
18	0	202.0	15	72	201.94	12	60	201.979	9	48	201.89	6	36	201.869	3	24	201.804	0	12	201.819
21	0	202.0	18	72	201.897	15	60	202.049	12	48	201.928	9	36	201.903	6	24	201.893	3	12	201.804
24	0	201.9	21	72	201.909	18	60	202.05	15	48	202.03	12	36	201.908	9	24	201.93	6	12	201.865
27	0	201.9	24	72	201.88	21	60	202.032	18	48	201.978	15	36	201.976	12	24	201.969	9	12	201.944
30	0	201.8	27	72	201.816	24	60	201.979	21	48	201.991	18	36	202.028	15	24	201.944	12	12	202
33	0	201.7	30	72	201.69	27	60	201.89	24	48	201.911	21	36	202.019	18	24	201.961	15	12	202.045
36	0	201.5	33	72	201.546	30	60	201.742	27	48	201.841	24	36	201.988	21	24	201.942	18	12	202.052
36	3	201.6	33	69	201.643	33	60	201.682	30	48	201.818	27	36	201.896	24	24	201.952	21	12	202.032
36	6	201.6	30	69	201.727	33	57	201.702	33	48	201.793	30	36	201.81	27	24	201.891	24	12	201.976
36	9	201.6	27	69	201.853	30	57	201.708	33	45	201.733	33	36	201.714	30	24	201.794	27	12	201.966
36	12	201.6	24	69	201.921	27	57	201.842	30	45	201.829	33	33	201.816	33	24	201.638	30	12	201.879
36	15	201.6	21	69	201.994	24	57	201.93	27	45	201.873	30	33	201.772	33	21	201.696	33	12	201.714
36	18	201.6	18	69	202.049	21	57	202.028	24	45	201.932	27	33	201.906	30	21	201.813	33	9	201.697
36	21	201.6	15	69	202.032	18	57	202.028	21	45	202.018	24	33	201.969	27	21	201.907	30	9	201.85
36	24	201.6	12	69	202.005	15	57	202.045	18	45	202.071	21	33	201.962	24	21	201.91	27	9	201.942
36	27	201.6	9	69	201.956	12	57	201.937	15	45	202.013	18	33	202.016	21	21	201.956	24	9	202.008
36	30	201.6	6	69	201.893	9	57	201.829	12	45	201.941	15	33	201.976	18	21	201.986	21	9	202.005
36	33	201.6	3	69	201.812	6	57	201.824	9	45	201.915	12	33	201.967	15	21	201.964	18	9	202.074
36	36	201.6	0	69	201.757	3	57	201.765	6	45	201.867	9	33	201.911	12	21	201.98	15	9	202.028
36	39	201.6	0	66	201.744	0	57	201.733	3	45	201.788	6	33	201.826	9	21	201.95	12	9	201.988
36	42	201.7	3	66	201.78	0	54	201.717	0	45	201.705	3	33	201.79	6	21	201.831	9	9	201.907
36	45	201.6	6	66	201.822	3	54	201.771	0	42	201.73	0	33	201.724	3	21	201.801	6	9	201.851
36	48	201.6	9	66	201.932	6	54	201.842	3	42	201.797	0	30	201.715	0	21	201.773	3	9	201.779
36	51	201.6	12	66	201.974	9	54	201.914	6	42	201.884	3	30	201.844	0	18	201.786	0	9	201.738
36	54	201.6	15	66	202.024	12	54	201.963	9	42	201.89	6	30	201.861	3	18	201.781	0	6	201.658
36	57	201.6	18	66	202.039	15	54	202.061	12	42	201.892	9	30	201.953	6	18	201.837	3	6	201.742
36	60	201.6	21	66	202.065	18	54	202.006	15	42	202.008	12	30	201.971	9	18	201.899	6	6	201.81

Table A-1. Prototype Hanford Barrier Surface Elevations (in Meters Above Mean Sea Level). Locations represent distance in meters from Stake 1,1 (Figure 1). (4 Pages)

July 1999																				
Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation	Location		Elevation
E	N		E	N		E	N		E	N		E	N		E	N		E	N	
36	63	201.6	24	66	201.953	21	54	202.016	18	42	202.077	15	30	201.988	12	18	201.969	9	6	201.876
36	66	201.6	27	66	201.837	24	54	201.941	21	42	202.022	18	30	201.983	15	18	201.956	12	6	201.959
36	69	201.5	30	66	201.749	27	54	201.887	24	42	201.941	21	30	202.004	18	18	202.01	15	6	202.005
36	72	201.5	33	66	201.625	30	54	201.736	27	42	201.852	24	30	201.943	21	18	201.997	18	6	202.061
33	75	201.5	33	63	201.689	33	54	201.71	30	42	201.792	27	30	201.835	24	18	201.92	21	6	202.011
30	75	201.7	30	63	201.762	33	51	201.678	33	42	201.744	30	30	201.739	27	18	201.885	24	6	201.966
27	75	201.757	27	63	201.897	30	51	201.792	33	39	201.711	33	30	201.656	30	18	201.799	27	6	201.929
24	75	201.746	24	63	201.988	27	51	201.837	30	39	201.795	33	27	201.693	33	18	201.694	30	6	201.822
21	75	201.685	21	63	202.053	24	51	201.932	27	39	201.855	30	27	201.8	33	15	201.703	33	6	201.67
18	75	201.849	18	63	202.047	21	51	202.003	24	39	201.918	27	27	201.837	30	15	201.822	33	3	201.649
15	75	201.914	15	63	202.031	18	51	202.076	21	39	202.015	24	27	201.94	27	15	201.937	30	3	201.806
12	75	201.893	12	63	202.005	15	51	202.022	18	39	202.017	21	27	201.964	24	15	201.937	27	3	201.894
9	75	201.8	9	63	201.894	12	51	201.939	15	39	201.954	18	27	201.982	21	15	202.025	24	3	201.913
6	75	201.786	6	63	201.82	9	51	201.886	12	39	201.905	15	27	201.999	18	15	202.007	21	3	201.97
																		18	3	202.006
																		15	3	201.991

Table A-2. Settlement Gauge Elevations (in Meters Above Mean Sea Level) at the Prototype Hanford Barrier.

Gauge	Dec-94	Sep-95	Jan-96	Sep-96	Jan-97	Sep-97	Jul-99
DSG-1	201.954	201.958	201.967	201.965	201.961	201.963	201.950
Change from December 1994	0	0.004	0.013	0.011	0.007	0.009	-0.004
DSG-2	201.687	201.690	201.698	201.698	201.686	201.698	201.683
Change from December 1994	0	0.003	0.011	0.011	-0.001	0.011	-0.004

Table A-3. July 1999 Prototype Hanford Barrier Creep Gauge Locations and Elevations (in Meters Above Mean Sea Level) with Changes from 1994 to 1997 and from 1994 to 1999.

Gauge #	29-Jul-99 Survey			Change From Last Survey (September 1997)					
	Northing	Easting	Elevation	delta N	delta E	delta Vertical	Horizontal Resultant	Bearing Degrees	Bearing Radians
1	137535.98	573524.44	200.225	0.001	0.025	-0.007	0.03	87.71	6.32
2	137544.97	573525.71	200.547	0.012	-0.014	0.001	0.02	310.60	2.43
3	137554.19	573525.72	200.251	0.007	-0.012	0.008	0.01	300.26	2.61
4	137563.11	573525.85	200.278	0.008	-0.004	0.000	0.01	333.43	2.03
5	137572.29	573525.90	200.293	0.015	-0.036	0.005	0.04	292.62	2.75
6	137578.01	573525.85	199.926	0.011	-0.018	0.011	0.02	301.43	2.59
7	137583.98	573525.53	200.192	0.015	-0.034	0.009	0.04	293.81	2.73
8	137588.73	573525.41	200.343	0.013	-0.026	0.003	0.03	296.57	2.68
9	137593.20	573525.56	200.181	0.014	-0.015	0.008	0.02	313.03	2.39
10a	137599.10	573524.08	200.794	0.009	-0.003	0.013	0.01	341.57	1.89
10b	137599.34	573526.16	199.600	0.013	-0.010	-0.001	0.02	322.43	2.23
11	137604.97	573525.74	200.264	0.015	-0.020	0.004	0.03	306.87	2.50
Gauge #	29-Jul-99 Survey			Change From First Survey (December 1994)					
	Northing	Easting	Elevation	delta N	delta E	delta Vertical	Horizontal Resultant	Bearing Degrees	Bearing Radians
1	137535.98	573524.44	200.225	0.000	0.061	-0.002	0.06	90.00	6.28
2	137544.97	573525.71	200.547	0.005	-0.008	-0.001	0.01	302.01	2.58
3	137554.19	573525.72	200.251	0.008	-0.001	0.008	0.01	352.87	1.70
4	137563.11	573525.85	200.278	0.020	0.011	-0.008	0.02	28.81	7.35
5	137572.29	573525.90	200.293	0.013	-0.032	-0.005	0.03	292.11	2.76
6	137578.01	573525.85	199.926	0.013	-0.015	0.012	0.02	310.91	2.43
7	137583.98	573525.53	200.192	0.008	-0.032	0.000	0.03	284.04	2.90
8	137588.73	573525.41	200.343	0.010	-0.020	0.003	0.02	296.57	2.68
9	137593.20	573525.56	200.181	0.008	0.005	0.003	0.01	32.01	7.30
10a	137599.10	573524.08	200.794	0.005	0.003	0.004	0.01	30.96	7.31
10b	137599.34	573526.16	199.600	0.010	-0.005	-0.004	0.01	333.43	2.03
11	137604.97	573525.74	200.264	0.011	0.003	-0.012	0.01	15.26	7.59

APPENDIX B

VEGETATION SURVEY MEASUREMENTS TAKEN AT THE PROTOTYPE HANFORD BARRIER, 1999

Table B-1. Nonirrigated Shrub Measurements.

Species		Height (cm)	Width (cm)	Length (cm)	Area (cm^2)
Artemisia tridentata (Big sagebrush)		45	30	40	1200.0
Artemisia tridentata (Big sagebrush)		84	47	60	2820.0
Artemisia tridentata (Big sagebrush)		68	50	91	4550.0
Artemisia tridentata (Big sagebrush)		59	40	66	2640.0
Artemisia tridentata (Big sagebrush)		65	37	48	1776.0
Artemisia tridentata (Big sagebrush)		95	75	85	6375.0
Artemisia tridentata (Big sagebrush)		60	55	55	3025.0
Artemisia tridentata (Big sagebrush)		50	42	48	2016.0
Artemisia tridentata (Big sagebrush)		70	63	70	4410.0
Artemisia tridentata (Big sagebrush)		64	55	68	3740.0
Artemisia tridentata (Big sagebrush)		55	27	40	1080.0
Artemisia tridentata (Big sagebrush)		57	40	50	2000.0
Artemisia tridentata (Big sagebrush)		68	40	88	3520.0
Artemisia tridentata (Big sagebrush)		66	50	60	3000.0
Artemisia tridentata (Big sagebrush)		73	45	65	2925.0
Artemisia tridentata (Big sagebrush)		65	35	65	2275.0
Artemisia tridentata (Big sagebrush)		62	45	65	2925.0
Artemisia tridentata (Big sagebrush)		58	40	75	3000.0
Artemisia tridentata (Big sagebrush)		81	55	70	3850.0
Artemisia tridentata (Big sagebrush)		63	45	60	2700.0
Artemisia tridentata (Big sagebrush)		54	60	65	3900.0
	Mean	64.86			3034.6
	Range	45 - 95			1080 - 6375
	Minimum	45			1080.0
	Maximum	95			6375.0

Species		Height (cm)	Width (cm)	Length (cm)	Area (cm^2)
Chrysothamnus nauseosus (Gray rabbitbrush)		42	18	27	486.0
Chrysothamnus nauseosus (Gray rabbitbrush)		40	42	50	2100.0
Chrysothamnus nauseosus (Gray rabbitbrush)		45	42	62	2604.0
Chrysothamnus nauseosus (Gray rabbitbrush)		38	42	35	1470.0
	Mean	41.25			1665.0
	Range	38 - 45			486 - 2604
	Minimum	38			486.0
	Maximum	45			2604.0

Table B-2. Irrigated Shrub Measurements.

Species	Height (cm)	Width (cm)	Length (cm)	Area (cm^2)
Artemisia tridentata (Big sagebrush)	71.12	50.8	25.4	1290.3
Artemisia tridentata (Big sagebrush)	78.74	45.72	43.18	1974.2
Artemisia tridentata (Big sagebrush)	66.04	66.04	58.42	3858.1
Artemisia tridentata (Big sagebrush)	76.2	76.2	58.42	4451.6
Artemisia tridentata (Big sagebrush)	53.34	55.88	33.02	1845.2
Artemisia tridentata (Big sagebrush)	60.96	48.26	38.1	1838.7
Artemisia tridentata (Big sagebrush)	55.88	53.34	22.86	1219.4
Artemisia tridentata (Big sagebrush)	68.58	58.42	48.26	2819.3
Artemisia tridentata (Big sagebrush)	66.04	71.12	58.42	4154.8
Artemisia tridentata (Big sagebrush)	66.04	50.8	50.8	2580.6
Artemisia tridentata (Big sagebrush)	58.42	68.58	45.72	3135.5
Artemisia tridentata (Big sagebrush)	78.74	66.04	50.8	3354.8
Artemisia tridentata (Big sagebrush)	63.5	63.5	58.42	3709.7
Artemisia tridentata (Big sagebrush)	40.64	25.4	25.4	645.2
Artemisia tridentata (Big sagebrush)	73.66	45.72	27.94	1277.4
Artemisia tridentata (Big sagebrush)	86.36	33.02	20.32	671.0
Artemisia tridentata (Big sagebrush)	48.26	15.24	12.7	193.5
Artemisia tridentata (Big sagebrush)	68.58	60.96	45.72	2787.1
Artemisia tridentata (Big sagebrush)	66.04	50.8	35.56	1806.4
Artemisia tridentata (Big sagebrush)	66.04	50.8	43.18	2193.5
Artemisia tridentata (Big sagebrush)	27.94	22.86	17.78	406.5
Artemisia tridentata (Big sagebrush)	71.12	78.74	58.42	4600.0
Mean	67		Mean	2419.7
Range	27.94 - 86.36		Range	193.5 - 4600
Minimum	27.94		Minimum	193.5
Maximum	86.36		Maximum	4600.0

Species	Height (cm)	Width (cm)	Length (cm)	Area (cm^2)
Chrysothamnus nauseosus (Gray rabbitbrush)	48.26	50.8	35.56	1806.4
Chrysothamnus nauseosus (Gray rabbitbrush)	50.8	48.26	38.1	1838.7
Chrysothamnus nauseosus (Gray rabbitbrush)	45.72	27.94	15.24	425.8
Mean	48.26		Mean	1357.0
Range	45.72 - 50.8		Range	425.8 - 1838.7
Minimum	45.72		Minimum	425.8
Maximum	50.8		Maximum	1838.7

Table B-3. Percent Canopy Cover on the Prototype Hanford Barrier.

	Irrigated (See cover classes and midpoints below)				
	Grass	Shrub	Forb	Litter	Bareground
Mean	68.3	27.7	2.5	78.4	16
Median	85	37.5	2.5	85	15
Mode	85	37.5	2.5	97.5	2.5
			Non-Irrigated		
Mean	40.1	38.3	2.5	59.7	28.5
Median	37.5	37.5	2.5	62.5	15
Mode	15	37.5	2.5	85	15

Canopy Cover Classes (Daubenmire 1959)

Class	Midpoint
0 to 5	2.5
5 to 25	15
25 to 50	37.5
50 to 75	62.5
75 to 95	85
95 to 100	97.5

Daubenmire, R. 1959. A Canopy-Coverage Method of Vegetational Analysis. Northwest Science 33:43-

Table B-4. Grass Canopy Cover Distribution on the Prototype Hanford Barrier. (5 Pages)

N

		1	2	3	4	5	6	7	8	9	10	11	12
IRRIGATED	25	85	85	85	85	85	62.5	85	97.5	97.5	97.5	97.5	85
	24	85	85	97.5	85	85	62.5	85	97.5	97.5	97.5	97.5	85
	23	62.5	15	37.5	15	15	15	85	85	97.5	97.5	97.5	85
	22	62.5	62.5	37.5	15	37.5	15	85	97.5	97.5	97.5	97.5	85
	21	37.5	37.5	37.5	37.5	37.5	37.5	62.5	62.5	62.5	62.5	85	62.5
	20	62.5	62.5	62.5	85	37.5	37.5	85	85	85	85	97.5	85
	19	62.5	85	37.5	37.5	85	37.5	62.5	62.5	85	85	97.5	62.5
	18	62.5	37.5	62.5	37.5	62.5	37.5	85	85	85	85	85	62.5
	17	62.5	62.5	62.5	37.5	37.5	37.5	85	85	62.5	85	97.5	85
	16	37.5	37.5	37.5	62.5	62.5	37.5	85	85	85	85	97.5	85
	15	62.5	37.5	37.5	37.5	37.5	15	62.5	85	97.5	85	85	85
NON-IRRIGATED	14	15	15	15	37.5	15	15	37.5	62.5	85	85	85	85
	13	15	15	15	37.5	37.5	15	37.5	62.5	62.5	62.5	62.5	62.5
	12	15	2.5	15	15	2.5	15	2.5	15	15	37.5	62.5	62.5
	11	15	15	15	2.5	2.5	2.5	2.5	2.5	15	37.5	85	62.5
	10	15	15	15	2.5	2.5	15	62.5	62.5	85	62.5	85	62.5
	9	15	15	15	15	15	15	62.5	62.5	85	62.5	85	85
	8	15	37.5	15	15	15	15	15	62.5	37.5	62.5	85	85
	7	37.5	15	37.5	2.5	2.5	15	37.5	62.5	62.5	62.5	62.5	62.5
	6	15	15	15	37.5	15	15	37.5	62.5	62.5	62.5	62.5	62.5
	5	37.5	15	15	15	15	37.5	62.5	62.5	85	85	85	85
	4	37.5	37.5	15	15	15	2.5	37.5	62.5	62.5	62.5	85	85
	3	37.5	2.5	15	37.5	15	2.5	37.5	37.5	85	62.5	85	85
	2	37.5	15	15	15	15	2.5	37.5	62.5	85	85	85	85
	1	62.5	62.5	37.5	37.5	15	15	37.5	37.5	62.5	85	85	85

Table B-4. Shrub Canopy Cover Distribution on the Prototype Hanford Barrier. (5 Pages)

N

		1	2	3	4	5	6	7	8	9	10	11	12
IRRIGATED	25	37.5	15	15	15	15	15	15	2.5	2.5	2.5	2.5	15
	24	15	37.5	62.5	15	62.5	15	15	15	2.5	2.5	2.5	37.5
	23	15	62.5	15	62.5	62.5	37.5	37.5	37.5	15	2.5	2.5	2.5
	22	37.5	62.5	37.5	37.5	37.5	37.5	15	15	15	15	37.5	37.5
	21	37.5	15	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	15	15
	20	15	37.5	15	37.5	37.5	37.5	62.5	37.5	15	15	15	15
	19	37.5	37.5	15	15	37.5	15	37.5	37.5	37.5	37.5	37.5	37.5
	18	62.5	15	37.5	15	15	37.5	37.5	37.5	15	15	15	37.5
	17	37.5	37.5	37.5	15	15	37.5	15	15	15	15	15	37.5
	16	37.5	15	37.5	15	37.5	15	37.5	37.5	15	15	15	15
	15	62.5	37.5	37.5	15	37.5	15	15	37.5	15	62.5	62.5	62.5
NON-IRRIGATED	14	37.5	37.5	37.5	37.5	15	15	37.5	15	37.5	37.5	15	15
	13	37.5	37.5	37.5	37.5	37.5	15	15	15	37.5	37.5	37.5	37.5
	12	37.5	37.5	37.5	37.5	37.5	15	37.5	15	37.5	37.5	37.5	37.5
	11	37.5	37.5	37.5	37.5	37.5	37.5	37.5	15	37.5	37.5	62.5	62.5
	10	37.5	37.5	15	37.5	37.5	15	37.5	37.5	62.5	15	37.5	62.5
	9	62.5	15	37.5	37.5	37.5	37.5	62.5	62.5	62.5	37.5	37.5	37.5
	8	37.5	37.5	37.5	37.5	37.5	37.5	62.5	62.5	37.5	37.5	37.5	37.5
	7	37.5	37.5	37.5	37.5	37.5	37.5	62.5	37.5	37.5	37.5	15	15
	6	62.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	15	15
	5	62.5	37.5	15	37.5	37.5	37.5	62.5	37.5	37.5	37.5	15	15
	4	62.5	37.5	37.5	37.5	37.5	37.5	62.5	37.5	37.5	62.5	37.5	15
	3	37.5	37.5	62.5	37.5	37.5	37.5	62.5	37.5	37.5	37.5	15	62.5
	2	37.5	37.5	62.5	37.5	62.5	37.5	37.5	62.5	62.5	37.5	37.5	15
	1	37.5	37.5	37.5	37.5	37.5	37.5	62.5	62.5	62.5	62.5	37.5	37.5

Table B-4. Forb Canopy Cover Distribution on the Prototype Hanford Barrier. (5 Pages)

N

		1	2	3	4	5	6	7	8	9	10	11	12
IRRIGATED	25	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	24	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	23	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	22	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	21	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	20	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	19	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	18	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	17	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	16	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NON-IRRIGATED	14	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	13	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	12	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	11	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	10	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	9	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	8	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	7	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	4	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Table B-4. Litter Canopy Cover Distribution on the Prototype Hanford Barrier. (5 Pages)

N ↑

		1	2	3	4	5	6	7	8	9	10	11	12
IRRIGATED	25	62.5	97.5	97.5	97.5	85	62.5	97.5	97.5	97.5	97.5	97.5	85
	24	97.5	97.5	97.5	85	85	62.5	97.5	97.5	97.5	97.5	97.5	97.5
	23	97.5	37.5	37.5	15	37.5	37.5	85	85	97.5	97.5	97.5	85
	22	85	62.5	37.5	37.5	37.5	37.5	85	97.5	97.5	97.5	97.5	85
	21	85	62.5	62.5	62.5	62.5	37.5	62.5	62.5	85	85	97.5	85
	20	85	85	62.5	85	62.5	62.5	62.5	97.5	85	97.5	97.5	85
	19	85	97.5	62.5	62.5	97.5	62.5	85	85	85	97.5	97.5	62.5
	18	62.5	62.5	85	62.5	85	62.5	85	85	97.5	97.5	97.5	62.5
	17	85	62.5	85	62.5	37.5	37.5	85	85	85	85	97.5	85
	16	62.5	62.5	62.5	85	85	62.5	97.5	85	97.5	97.5	97.5	85
	15	85	37.5	62.5	62.5	62.5	37.5	85	85	97.5	85	97.5	85
NON-IRRIGATED	14	62.5	37.5	37.5	37.5	37.5	37.5	62.5	85	97.5	97.5	97.5	85
	13	62.5	37.5	37.5	37.5	37.5	37.5	62.5	85	85	85	85	97.5
	12	37.5	37.5	15	15	15	37.5	37.5	85	85	85	85	97.5
	11	37.5	37.5	37.5	15	62.5	37.5	37.5	37.5	85	85	85	85
	10	62.5	37.5	37.5	37.5	15	37.5	62.5	62.5	85	85	85	62.5
	9	85	37.5	62.5	15	62.5	37.5	62.5	85	85	85	85	85
	8	62.5	37.5	37.5	37.5	62.5	15	37.5	85	62.5	62.5	85	85
	7	62.5	37.5	37.5	15	15	37.5	37.5	62.5	62.5	85	85	62.5
	6	85	37.5	37.5	37.5	62.5	37.5	85	85	85	62.5	85	85
	5	62.5	37.5	37.5	15	37.5	37.5	62.5	85	85	85	85	85
	4	85	62.5	37.5	62.5	62.5	62.5	85	85	85	85	85	85
	3	62.5	37.5	15	37.5	15	15	62.5	85	85	85	85	85
	2	85	62.5	62.5	37.5	15	37.5	62.5	85	85	85	85	97.5
	1	2.5	62.5	37.5	37.5	37.5	37.5	37.5	62.5	62.5	85	97.5	97.5

Table B-4. Bare Ground Canopy Cover Distribution on the Prototype Hanford Barrier. (5 Pages)

N

		1	2	3	4	5	6	7	8	9	10	11	12
IRRIGATED	25	2.5	15	2.5	2.5	15	15	2.5	2.5	2.5	2.5	2.5	2.5
	24	2.5	2.5	2.5	2.5	15	15	2.5	2.5	2.5	2.5	2.5	2.5
	23	2.5	15	37.5	37.5	37.5	62.5	2.5	15	2.5	2.5	2.5	15
	22	15	15	37.5	15	37.5	37.5	15	2.5	2.5	2.5	2.5	2.5
	21	15	15	37.5	37.5	37.5	62.5	15	15	15	15	2.5	15
	20	15	15	15	15	15	62.5	15	2.5	2.5	2.5	2.5	15
	19	37.5	15	15	37.5	15	37.5	15	2.5	2.5	2.5	2.5	15
	18	37.5	15	15	37.5	15	37.5	2.5	15	2.5	2.5	2.5	15
	17	37.5	15	15	37.5	37.5	37.5	2.5	2.5	15	2.5	2.5	15
	16	37.5	62.5	37.5	37.5	37.5	37.5	2.5	2.5	2.5	2.5	2.5	15
	15	15	37.5	37.5	15	37.5	37.5	15	2.5	2.5	2.5	2.5	15
NON-IRRIGATED	14	37.5	62.5	62.5	37.5	62.5	62.5	37.5	15	2.5	2.5	2.5	15
	13	62.5	37.5	62.5	37.5	37.5	62.5	37.5	15	2.5	15	2.5	2.5
	12	37.5	62.5	62.5	85	85	85	37.5	15	15	15	15	2.5
	11	62.5	62.5	62.5	62.5	62.5	62.5	37.5	37.5	15	15	15	15
	10	37.5	37.5	37.5	37.5	37.5	62.5	15	15	15	15	15	37.5
	9	15	37.5	37.5	37.5	37.5	37.5	15	15	2.5	15	15	15
	8	15	15	15	37.5	37.5	62.5	37.5	15	37.5	15	15	15
	7	15	37.5	37.5	37.5	62.5	37.5	37.5	37.5	37.5	15	15	15
	6	15	37.5	37.5	62.5	37.5	37.5	15	15	15	15	15	15
	5	15	37.5	37.5	37.5	37.5	62.5	37.5	15	15	15	15	2.5
	4	15	37.5	37.5	15	37.5	37.5	15	15	15	15	15	15
	3	15	37.5	37.5	15	37.5	37.5	15	15	15	15	15	15
	2	2.5	15	15	15	15	37.5	37.5	15	2.5	15	15	2.5
	1	15	15	15	37.5	37.5	37.5	37.5	37.5	15	15	2.5	2.5

Table B-5. Percent Total Canopy Cover on the Prototype Hanford Barrier.

	Row	Grass	Shrub	Forb	Litter	Baregound
IRRIGATED	25	87.3	12.7	2.5	89.6	5.6
	24	88.3	23.5	2.5	92.5	4.6
	23	59	29.4	2.5	67.5	19.4
	22	65.8	32.1	2.5	71.5	15.4
	21	51.9	31.9	2.5	70.8	23.5
	20	72.5	28.3	2.5	80.6	14.8
	19	66.7	31.9	2.5	81.7	16.5
	18	65.6	28.3	2.5	78.8	16.5
	17	66.7	24.4	2.5	74.4	18.3
	16	66.5	24.4	2.5	81.7	23.1
	15	60.6	38.8	2.5	73.5	18.3
	MEAN	68.3	27.7	2.5	78.4	16
NON-IRRIGATED	14	46	28.1	2.5	64.6	33.3
	13	40.4	31.9	2.5	62.5	31.3
	12	21.7	33.8	2.5	52.7	43.1
	11	21.5	39.8	2.5	53.5	42.5
	10	40.4	36	2.5	55.8	30.2
	9	44.4	44	2.5	65.6	23.3
	8	38.3	41.7	2.5	55.8	26.5
	7	38.3	35.8	2.5	50	32.1
	6	38.5	35.8	2.5	65.4	26.5
	5	50.0	36	2.5	59.6	27.3
	4	43.1	41.9	2.5	73.5	22.5
	3	41.9	41.9	2.5	55.8	22.5
	2	45	44	2.5	66.1	15.6
	1	51.9	45.8	2.5	54.8	22.3
	MEAN	40.1	38.3	2.5	59.7	28.5